MERRA

Model bias correction concepts

5 September, 2006

Current status of GEOS-5 moisture: slides 3-5

The bias problems, model and observations: slides 6-9

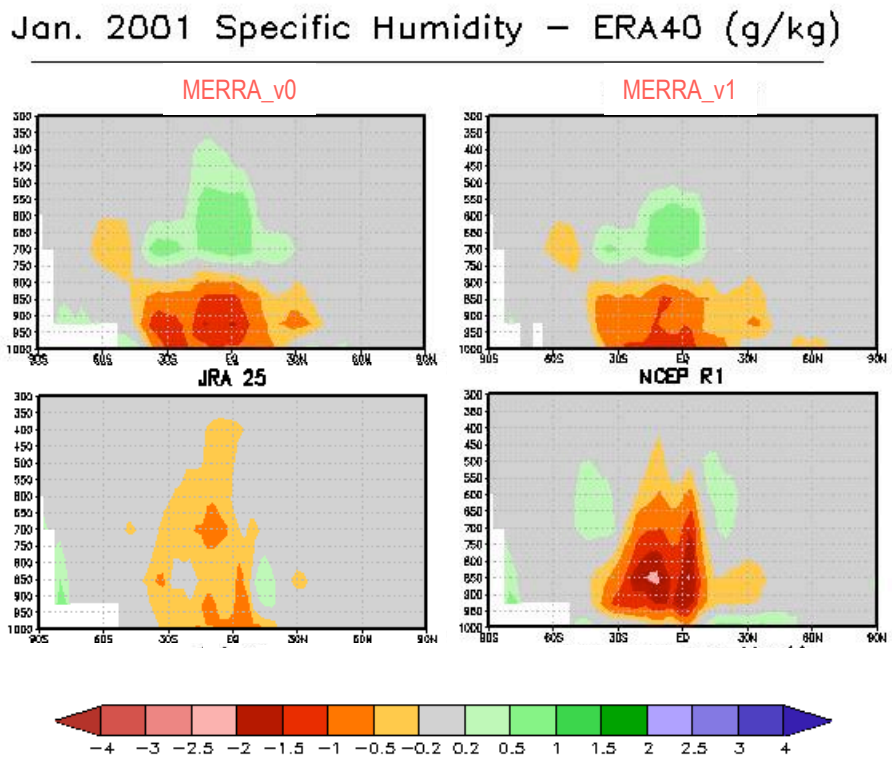
Our proposed solution: slides 10-11

2° MERRA tests

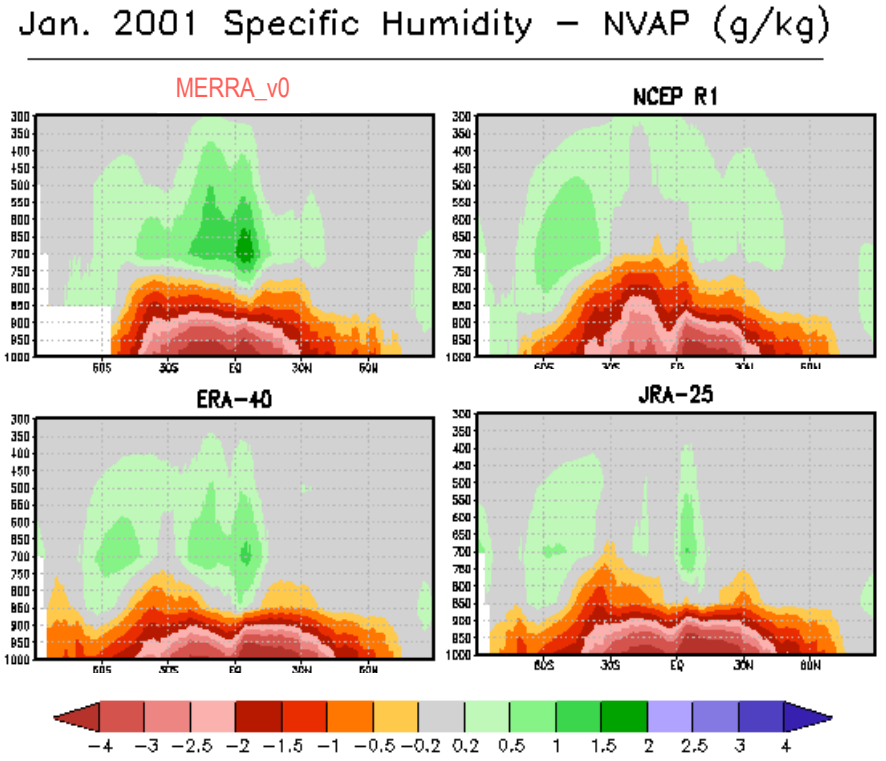
What is the moisture bias?

January 2001 Specific Humidity (g/kg)

Comparisons with ERA-40



Comparisons with NVAP

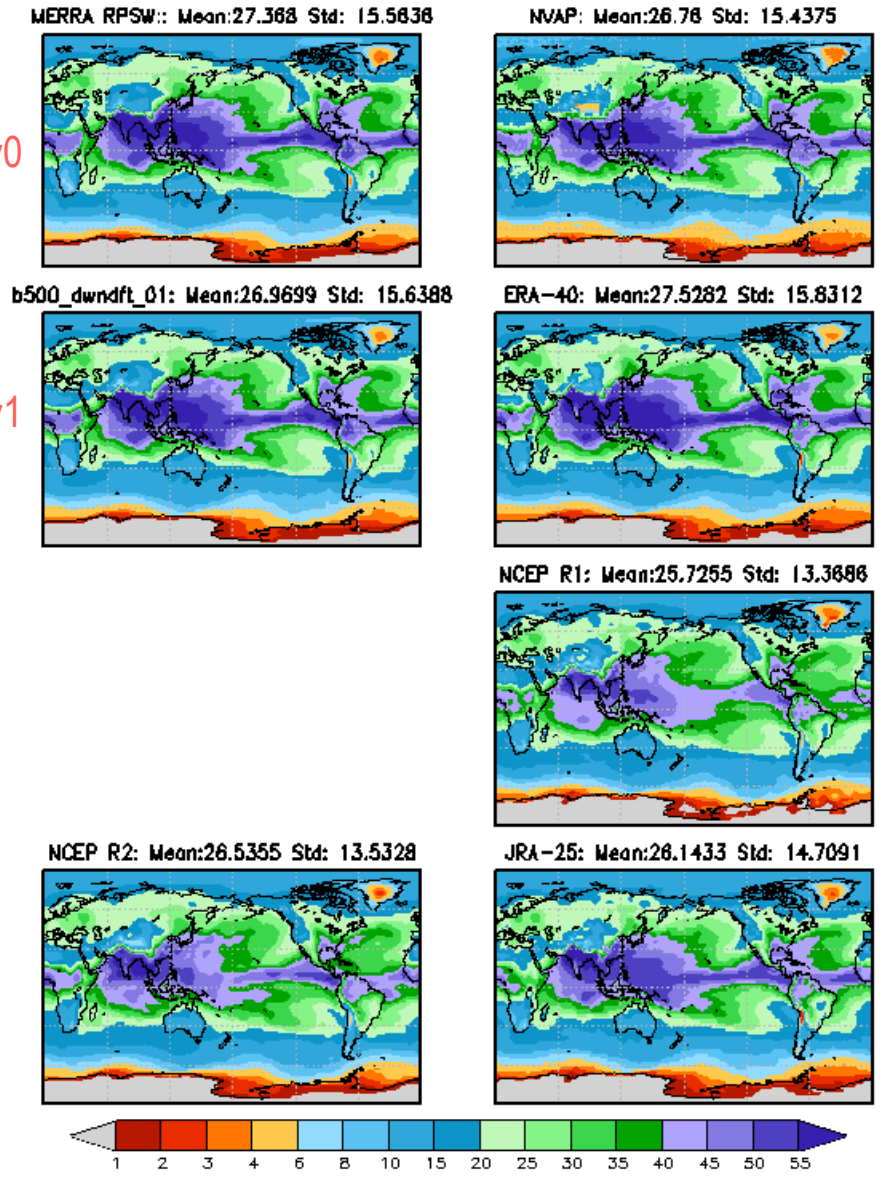


2° MERRA tests

July 2001 TPW (mm)

MERRA_v0

MERRA_v1

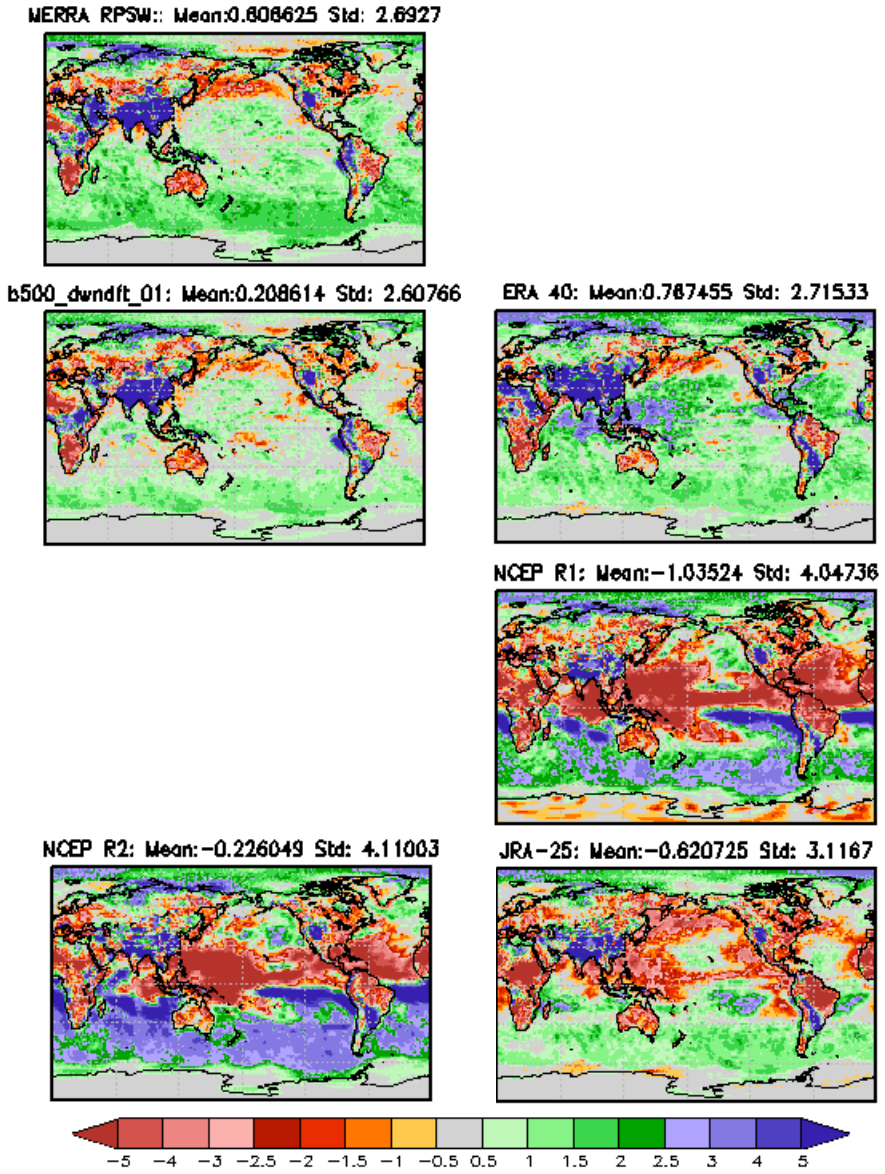


2° MERRA tests

July 2001 TPW - NVAP (mm)

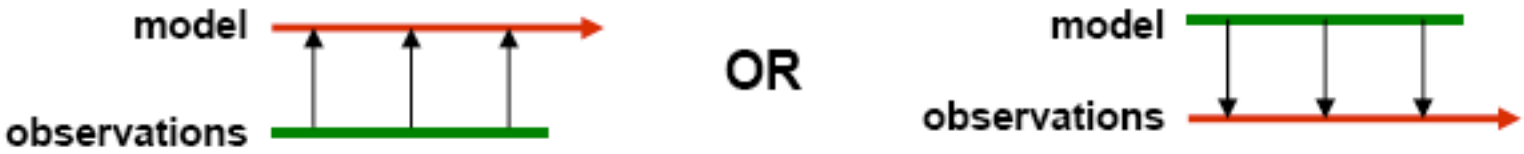
MERRA_v0

MERRA_v1



Correcting Biases

Both model and observations have biases - sometimes in the same quantity
Challenge: distinguishing the source



The GSI analysis system has an adaptive *observational bias* correction scheme:

- Estimates satellite bias corrections in real time during the assimilation
- Adapts to slow changes in the bias, instrument drift, etc
- Cleanly handles abrupt changes (new sensors, sensor failure)

The GSI analysis system also has an online *model bias* correction scheme

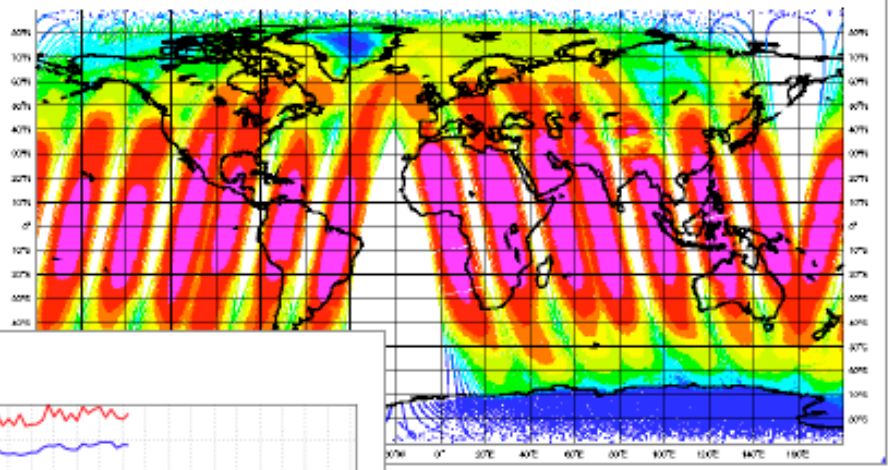
- Estimates are slowly evolving
- Needs source of unbiased data
- We have introduced the estimation on a diurnal basis
- Benefit: more effective use of satellite data to correct random errors

Biases in radiance data

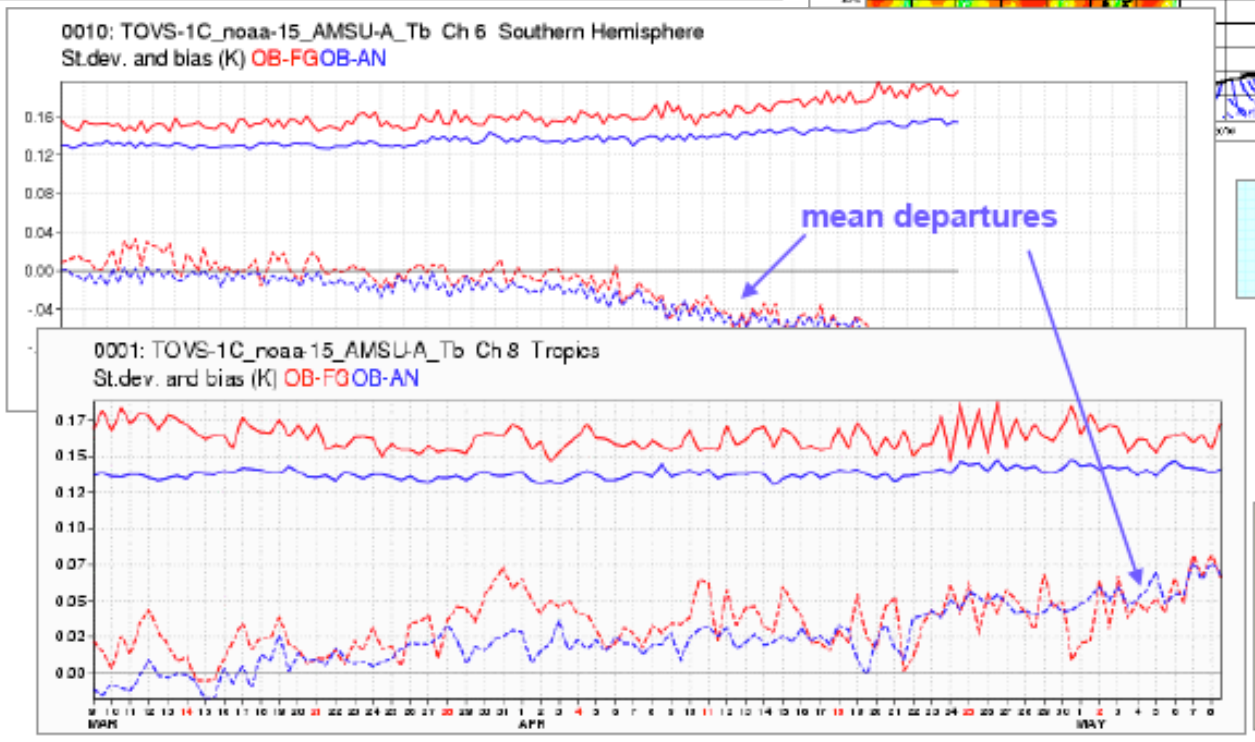
From Dee (2006)

Non-physical scan-angle dependence of observed brightness temperatures

AMSUA-channel 5 brightness temperatures



Shift in mean residuals between observed radiances and model-simulated radiances



Instrument failure ?
Sensor calibration ?

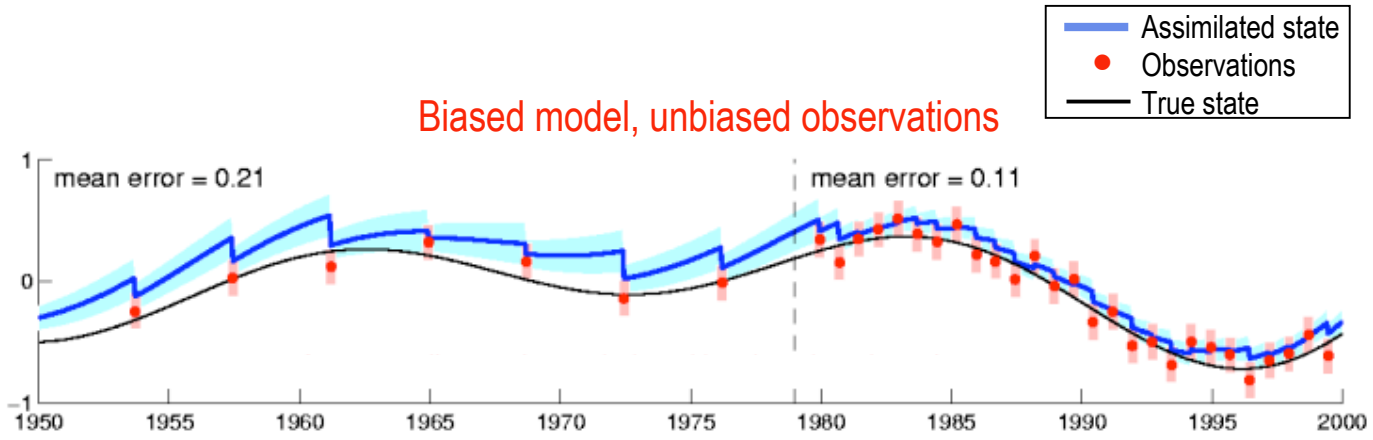
Errors in radiative transfer model ?

Biases are complex, flow-dependent, and different for each satellite/sensor/channel

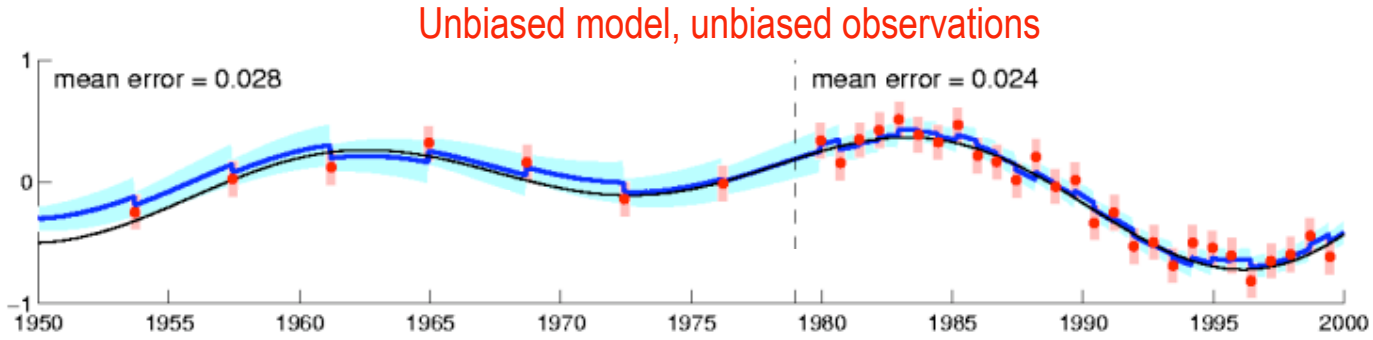
The problem with model bias: Using new observations to correct model bias impacts the character of the reanalysis time series (not a problem for NWP)

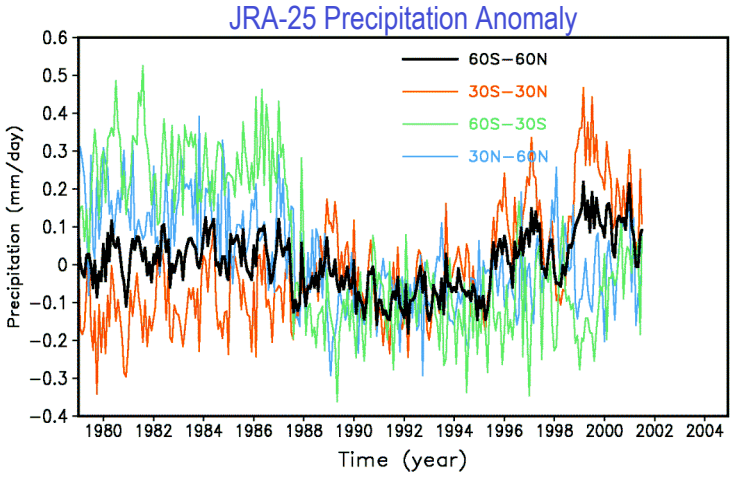
[slide follows Dee and daSilva (1998)]

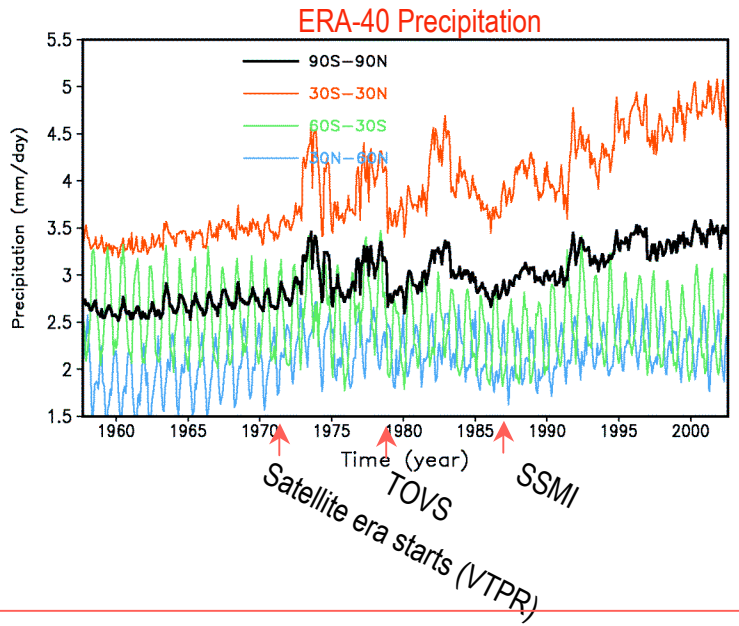
- Model errors are systematic
- Mean analysis increment is non-zero
- Change in observing system impacts the character of the time series
- More observations potentially reduce systematic analysis errors



- Model errors are randomly distributed about true state
- Mean analysis increment is close to zero
- Change in observing system does not change the character of the state or the errors







In JRA-25 the impact of SSMI has a significant effect on the time series of precipitation.

In ERA-40 we see the impact of changes in the observing system, lack of adaptive bias correction, and (most likely) model error.

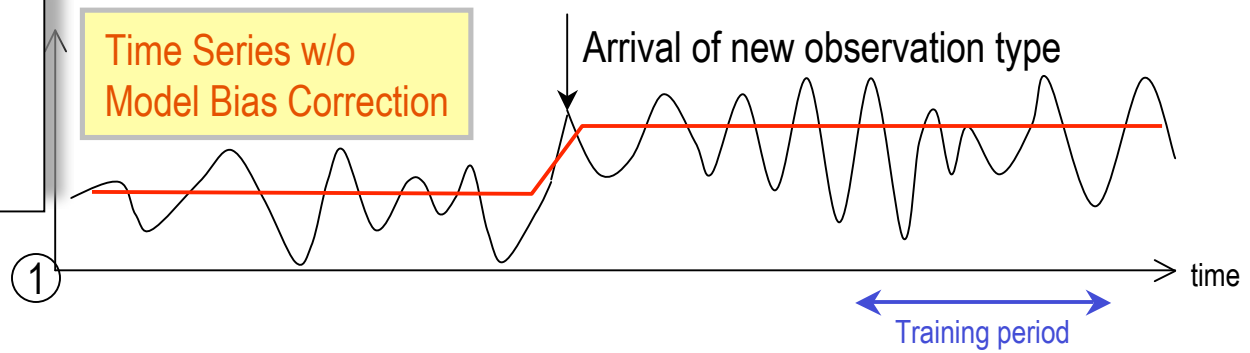
GMAO Proposed Approach to model bias in reanalysis

• Estimating the model bias: Use online model bias estimation from the DAS to obtain diurnal and seasonal components of moisture bias correction from a recent multi-year assimilation (denoted the 'training period'; use 1 degree resolution). Generate a climatological bias estimate (diurnal and seasonally varying only) from the evolving multi-year bias estimates.

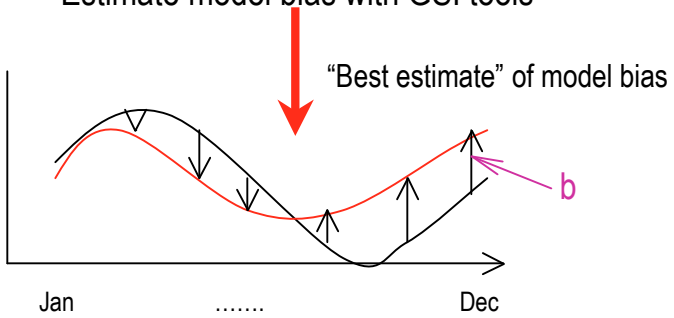
• Implementation: Apply only this fixed climatological correction *during the whole reanalysis period*. The evolving model bias correction estimate from the GSI is disabled. Observational bias correction must be enabled throughout.

• Validation: Repeat training period using fixed correction; also test SSMI transition period.

Implementation of the Model Climatological Moisture Bias Correction



② **Training period** - uses online model bias estimation
Good source of high quality moisture data
Estimate model bias with GSI tools



③ Following the bias estimation, the analysis is based on difference between observations and unbiased model forecast where the bias adjustment is applied throughout the entire re-analysis period. In sequential estimation:

$$\tilde{\mathbf{x}}_n^b = \mathbf{x}_n^b - \mathbf{b}$$

$$\tilde{\mathbf{x}}_n^a = \tilde{\mathbf{x}}_n^b + \mathbf{K}_n\{\mathbf{y}_n^o - \mathbf{H}(\tilde{\mathbf{x}}_n^b)\}$$

$\mathbf{b}$ is the climatological model bias estimate
$\tilde{\mathbf{x}}_n^b$ is the unbiased background estimate at analysis time *n*
$\tilde{\mathbf{x}}_n^a$ is the unbiased analysis estimate at analysis time *n*
$\mathbf{y}_n^o$ is the unbiased observation at analysis time *n*
$\mathbf{x}_n^b$ is the biased background estimate at analysis time *n*
$\mathbf{K}_n$ is the analysis weight matrix
$\mathbf{H}$ is the observation operator

④